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(54) **VEHICLE HAVING AN INTEGRATED AIR CURTAIN AND BRAKE COOLING DUCT**

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F16D 65/847 (2006.01)

(52) **U.S. Cl.**
CPC ***B62D 35/02*** (2013.01); ***F16D 65/847*** (2013.01)

(58) **Field of Classification Search**
CPC B62D 35/02; F16D 65/847
USPC 296/180.1
See application file for complete search history.

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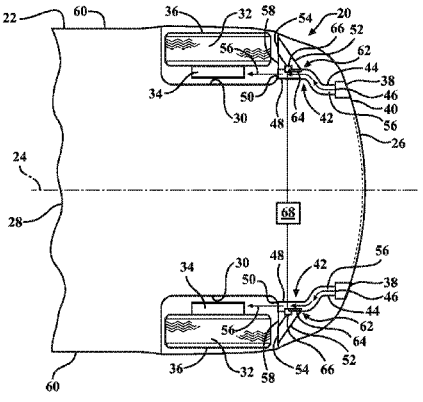
(57) **ABSTRACT**

A vehicle includes an air intake opening disposed at a forward end of a body, and a duct, having an air inlet, a first outlet, and a second outlet. The air inlet is disposed adjacent the air intake opening. The first outlet is configured for directing the flow of air across a brake system. The second outlet is configured for directing the flow of air across an exterior surface of a wheel. A shutter is disposed within the duct, and is moveable between a first position and a second position. When disposed in the first position, the airflow control mechanism is configured for directing the flow of air through the first outlet and blocking airflow through the second outlet. When disposed in the second position, the airflow control mechanism is configured for directing the flow of air through the second outlet and blocking airflow through the first outlet.

18 Claims, 2 Drawing Sheets



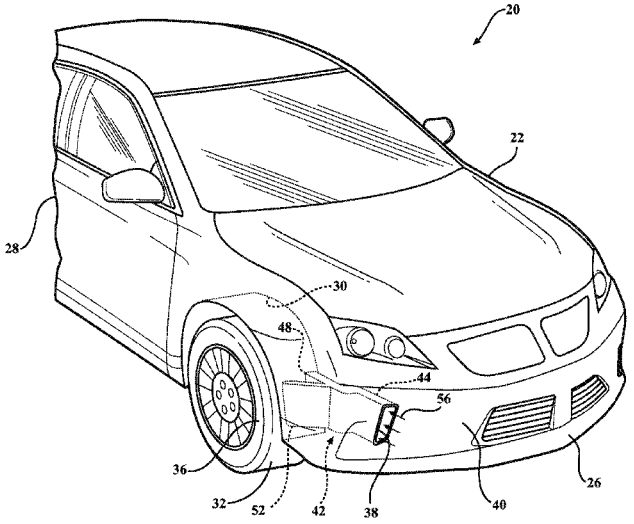


FIG. 1

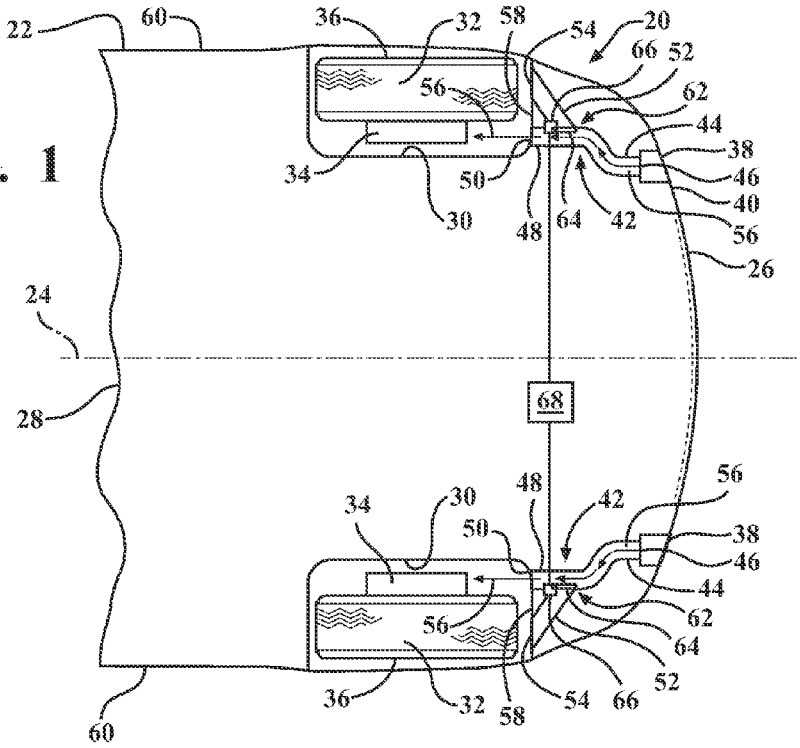

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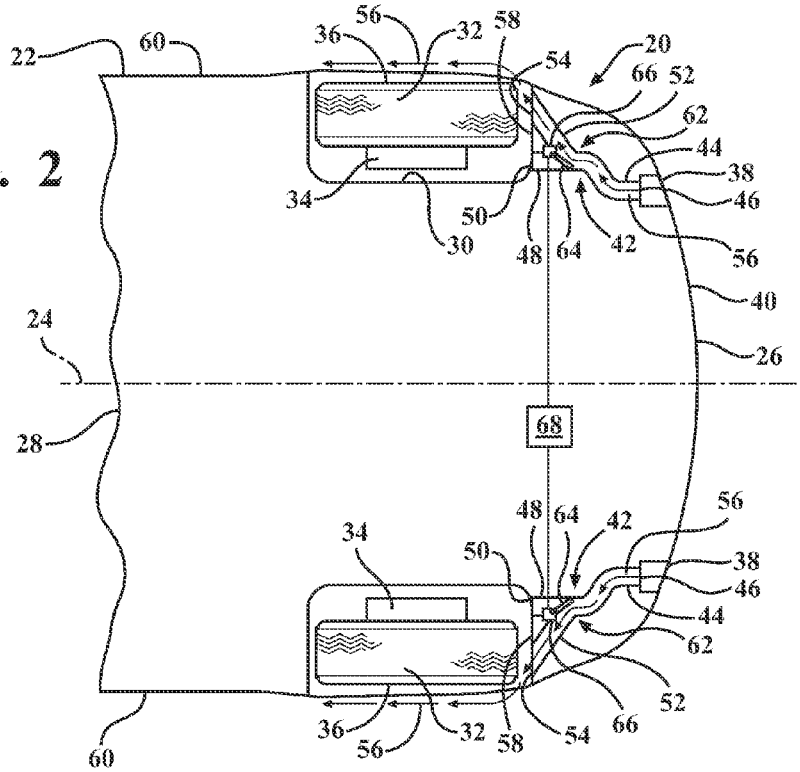
FIG. 2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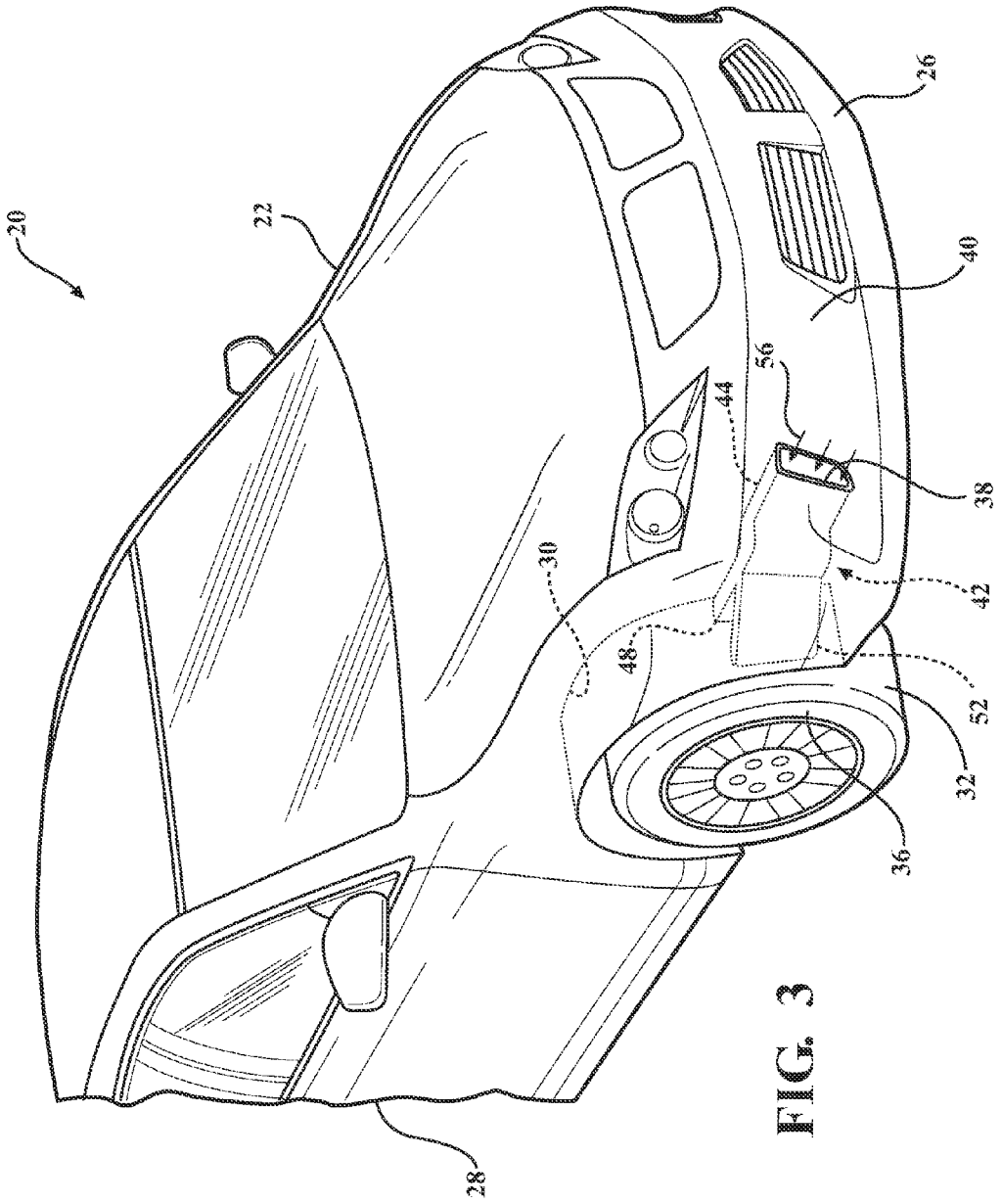

FIG. 3

VEHICLE HAVING AN INTEGRATED AIR CURTAIN AND BRAKE COOLING DUCT

TECHNICAL FIELD

The disclosure generally relates to a vehicle.

BACKGROUND

Some vehicles are now being designed to form an air curtain over the front wheels of the vehicle for reducing turbulence, and improving fuel efficiency. In order to form the air curtain, the front fascia of the body is equipped with an opening in the front fascia, located at a lower, front corner of the body. Air ducts route a flow of high pressure air from the opening to an outlet that is disposed at a forward edge of the front wheel well, adjacent the side of the body. The flow of air is discharged at a high speed, and flows across and covers the exterior of the front wheels like a curtain, thereby reducing undesirable aerodynamic turbulence around the rotating wheels.

Some vehicles also include a brake cooling system. The brake cooling system includes an inlet or opening disposed at the forward end of the vehicle, and collects a flow of air which is directed to a brake system, through one or more air ducts, to cool the brake system. Typically, the inlet of the brake duct is in fluid communication with a brake cooling opening in the forward end of the body, often disposed at an outboard lower vertical edge of the forward end of the body. The air flows through the brake cooling opening and through the brake duct continuously when the vehicle is in motion, even when the brake system does not require cooling. This continuous airflow through the brake cooling opening and brake duct introduces a constant aerodynamic drag onto the vehicle, thereby limiting the performance of the vehicle and reducing fuel efficiency of the vehicle.

SUMMARY

A vehicle includes a body that extends along a longitudinal axis. The body defines an air intake opening configured for receiving a flow of air. At least one duct, having an air inlet, is disposed adjacent the air intake opening of the body, and is configured for receiving the flow of air through the air intake opening. The duct further includes a first outlet in fluid communication with the air inlet and configured for directing the flow of air across a brake system, and a second outlet in fluid communication with the air inlet and configured for directing the flow of air across an exterior surface of a wheel to form an air curtain over the wheel. An airflow control mechanism is moveable between a first position and a second position. When disposed in the first position, the airflow control mechanism is configured for directing the flow of air through the first outlet and blocking airflow through the second outlet. When disposed in the second position, the airflow control mechanism is configured for directing the flow of air through the second outlet and blocking airflow through the first outlet.

Accordingly, the vehicle is equipped with a single air intake opening, located in the front of the vehicle, which supplies a flow of air to both the first outlet, i.e., a brake cooling duct outlet, and the second outlet, i.e., an air curtain outlet. The airflow control mechanism controls the flow of air between the two different outlets. This configuration uses the single air intake opening for both functions, thereby minimizing the number of openings in the front fascia of the vehicle, and reducing the packaging requirements of the air ducts between the front of the vehicle and their respective outlets. Additionally, the vehicle may control which one of the duct outlets the air is directed to in order to improve fuel efficiency and/or performance.

The above features and advantages and other features and advantages of the present teachings are readily apparent from the following detailed description of the best modes for carrying out the teachings when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic plan view of a vehicle showing an airflow control system in a first position directing a flow of air across a brake system of an associated front wheel.

FIG. **2** is a schematic plan view of the vehicle showing the airflow control system in a second position directing a flow of air across an exterior surface of the front wheel.

FIG. **3** is a schematic perspective view of a forward end of the vehicle showing an air intake opening in the body.

DETAILED DESCRIPTION

Those having ordinary skill in the art will recognize that terms such as "above," "below," "upward," "downward," "top," "bottom," etc., are used descriptively for the figures, and do not represent limitations on the scope of the disclosure, as defined by the appended claims. Furthermore, the teachings may be described herein in terms of functional and/or logical block components and/or various processing steps. It should be realized that such block components may be comprised of any number of hardware, software, and/or firmware components configured to perform the specified functions.

Referring to the Figures, wherein like numerals indicate like parts throughout the several views, a vehicle is generally shown at **20**. The vehicle **20** may include any type, size and/or style of vehicle, including but not limited to a passenger car, a truck, a van, etc.

Referring to FIGS. **1** and **2**, the vehicle **20** includes a body **22** that extends along a longitudinal axis **24**. The longitudinal axis **24** extends through a center of the vehicle **20**. The body **22** extends along the longitudinal axis **24**, between a forward end **26**, i.e., a front of the vehicle **20**, and a rearward end **28**, i.e., a back of the vehicle **20**. As described herein, the term "body **22**" is used generically, and should be interpreted to include all structural components of the vehicle **20**, including a frame, suspension components, exterior panels, etc.

The body **22** defines a forward wheel well **30**, which is disposed axially rearward of the forward end **26** the body **22**. It should be appreciated that the vehicle **20** may define two forward wheel wells **30**, one on opposing lateral sides of the vehicle **20**. While the written description below refers to only a single wheel well **30**, it should be appreciated that the disclosure may be applied to both forward wheel wells **30**. It should also be appreciated that the teachings of the disclosure may be incorporated into the rearward wheel wells **30** of the vehicle **20** as well, although not specifically described herein.

The vehicle **20** includes a wheel **32**, and an associated brake system **34**, disposed within the wheel well **30**. The wheel **32** is rotatably attached to the frame of the vehicle **20**, as is known in the art. The brake system **34** is attached to the wheel **32**, and is operable to decelerate the wheel **32** as is known in the art. As is known, the wheel **32** is generally tucked within the wheel well **30**, such that only an exterior

surface **36** of the wheel **32** is exposed. The brake system **34** is generally positioned within an interior of the wheel **32**.

Referring to FIG. **3**, the body **22** further defines an air intake opening **38** disposed at the forward end **26** of the body **22**. Preferably, the air intake opening **38** is an opening that is defined by a front fascia **40** of the body **22**, and is preferably disposed adjacent a lower, front corner of the body **22**. The forward wheel well **30** is disposed rearward of the air intake opening **38**, along the longitudinal axis **24**. The air intake opening **38** is configured for collecting and directing a flow of air through to an air control system **42**, described in greater detail below.

Referring to FIGS. **1** and **2**, the air control system **42** includes at least one air duct and an airflow control mechanism **62**. As shown, the at least one air duct includes an inlet duct portion **44** defining an air inlet **46**, a first duct outlet portion **48** defining a first outlet **50**, and a second duct outlet portion **52** defining a second outlet **54**. The air inlet **46** of the inlet duct portion **44** is disposed adjacent the air intake opening **38**, and is configured for receiving the flow of air through the air intake opening **38**. The flow of air is generally indicated by arrows **56**. The inlet duct portion **44** extends rearward toward the wheel well **30**. The first duct outlet portion **48** is disposed in fluid communication with the inlet duct portion **44**, and conducts the flow of air from the inlet duct portion **44** to the first outlet **50**. Accordingly, the first outlet **50** is disposed in fluid communication with the air inlet **46**. As shown in FIG. **1**, the first outlet **50** is configured for directing the flow of air across the brake system **34** to cool the brake system **34**. The second duct outlet portion **52** is disposed in fluid communication with the inlet duct portion **44**, and conducts the flow of air from the inlet duct portion **44** to the second outlet **54**. Accordingly, the second outlet **54** is disposed in fluid communication with the air inlet **46**. As shown in FIG. **2**, the second outlet **54** is configured for directing the flow of air across the exterior surface **36** of the wheel **32** to form an air curtain over the wheel **32**. Accordingly, it should be appreciated that the single air inlet **46**, adjacent the air intake opening **38**, provides the flow of air to both the first outlet **50** for cooling the brakes, and/or to the second outlet **54** for creating an air curtain over the front wheel **32**.

The second outlet **54**, which is configured for creating the air curtain over the front wheel **32**, is disposed adjacent a forward edge **58** of the wheel well **30**, and adjacent a lateral, exterior side surface **60** of the body **22**. The second outlet **54** is sized to generate high speed air flow across the exterior surface **36** of the wheel **32**, which covers the exterior surface **36** of the wheel **32** like a curtain, thereby reducing turbulence around the rotating wheel **32**, and improving the aerodynamics of the vehicle **20**. The first outlet **50** is disposed laterally inboard of the second outlet **54**, relative to the longitudinal axis **24**, and is positioned to direct the flow of air onto and across the brake system **34**, which is disposed nearer the inboard side of the wheel well **30**. As used herein, the term inboard is defined as being nearer the central, longitudinal axis **24** of the vehicle **20**. Accordingly, the first outlet **50**, for cooling the brake system **34**, is disposed nearer the longitudinal axis **24** of the vehicle **20** than is the second outlet **54**, for forming the air curtain over the exterior surface **36** of the wheel **32**.

The vehicle **20** includes an airflow control mechanism **62** operable to control the flow of air through the air ducts **44**, **48**, **52**, from the air inlet **46** and to either of the first outlet **50** and/or the second outlet **54**. Preferably, the airflow control mechanism **62** includes a shutter **64** that is disposed within the air ducts **44**, **48**, **52**, at an intersection of the inlet duct portion **44**, the first duct outlet portion **48**, and the second duct outlet portion **52**. However, it should be appreciated that the airflow control mechanism **62** may be configured in some other manner not shown or described herein that is capable of selectively directing the flow of air between the first outlet **50** and the second outlet **54**.

The airflow control mechanism **62**, and more specifically, the shutter **64**, is moveable between at least a first position, shown in FIG. **1**, and a second position, shown in FIG. **2**. When disposed in the first position, the shutter **64** is configured or positioned within the ducts to direct the flow of air through the first outlet **50**, and block airflow through the second outlet **54**. As such, when disposed in the first position, the shutter **64** opens fluid communication between the air inlet **46** and the first outlet **50**, and closes fluid communication between the air inlet **46** and the second outlet **54**. Accordingly, when the shutter **64** is disposed in the first position, the flow of air is directed through the first outlet **50** to cool the brake system **34**. When disposed in the second position the shutter **64** is configured or positioned within the ducts to direct the flow of air through the second outlet **54**, and block airflow through the first outlet **50**. As such, when disposed in the second position, the shutter **64** opens fluid communication between the air inlet **46** and the second outlet **54**, and closes fluid communication between the air inlet **46** and the first outlet **50**. Accordingly, when the shutter **64** is disposed in the second position, the flow of air is directed through the second outlet **54** to form the air curtain over the exterior surface **36** of the wheel **32**.

The airflow control mechanism **62**, more specifically the shutter **64**, may further be moveable into a third position. The third position may be defined as an intermediate position disposed between the first position and the second position. When positioned in the third position, the shutter **64** is configured or positioned within the ducts to simultaneously direct the flow of air through both the first outlet **50** and the second outlet **54**. As such, when disposed in the third position, the shutter **64** simultaneously opens fluid communication between the air inlet **46** and both of the first outlet **50** and the second outlet **54**. Accordingly, when the shutter **64** is disposed in the third position, the flow of air is directed through both the first outlet **50** and the second outlet **54** to simultaneously cool the brake system **34** and form the air curtain over the exterior surface **36** of the wheel **32**.

The airflow control mechanism **62** further includes an actuator **66** that is coupled to the shutter **64**. The actuator **66** is operable to move the shutter **64** between the first position and the second position. The actuator **66** may also be configured to move the shutter **64** into the third position, i.e., an intermediate position between the first position and the second position. The actuator **66** may include, but is not limited to, one of an electronic actuator, a pneumatic actuator, a vacuum actuator, a hydraulic actuator, or some other device capable of moving the shutter **64**, or controlling the flow of air from between the air inlet **46**, the first outlet **50**, and the second outlet **54**.

A vehicle controller **68** is operable to control the airflow control mechanism **62**, and more specifically the actuator **66**. The vehicle controller **68** may include tangible, non-transitory memory on which is recorded computer-executable instructions including an air control module, and a processor configured for executing the air control module. The air control module is configured for determining an optimal position for the shutter **64** for the current operating conditions of the vehicle **20**, and signaling the actuator **66** to position the shutter **64** in the optimal position. As such, the air control module determines which position, i.e., the first

position, the second position, or the third position, is the optimal position of the shutter **64** given the vehicle's **20** current operating condition, and then signals the actuator **66** to move or position the shutter **64** into the optima position.

The vehicle controller **68** may be embodied as one or multiple digital computers or host machines each having one or more processors, read only memory (ROM), random access memory (RAM), electrically-programmable read only memory (EPROM), optical drives, magnetic drives, etc., a high-speed clock, analog-to-digital (A/D) circuitry, digital-to-analog (D/A) circuitry, and any required input/output (I/O) circuitry, I/O devices, and communication interfaces, as well as signal conditioning and buffer electronics.

The computer-readable memory may include any non-transitory/tangible medium which participates in providing data or computer-readable instructions. Memory may be non-volatile or volatile. Non-volatile media may include, for example, optical or magnetic disks and other persistent memory. Example volatile media may include dynamic random access memory (DRAM), which may constitute a main memory. Other examples of embodiments for memory include a floppy, flexible disk, or hard disk, magnetic tape or other magnetic medium, a CD-ROM, DVD, and/or any other optical medium, as well as other possible memory devices such as flash memory.

When the brake system **34** is engaged to decelerate the vehicle **20**, the brake system **34** generates heat. Accordingly, when the vehicle controller **68** determines that the brake system **34** is currently being engaged, then the vehicle controller **68** may signal the actuator **66** to move the shutter **64** into the first position, to direct the flow of air entering the air intake opening **38**, through the first outlet **50** for cooling the brake system **34**. However, if the vehicle controller **68** determines that the brake system **34** is not currently being engaged, or otherwise does not require cooling, then the vehicle controller **68** may signal the actuator **66** to move the shutter **64** into the second position, to form the air curtain over the front wheel **32**, to improve the aerodynamic performance of the body **22**. The vehicle controller **68** may make the determination of which position is the optimal position for the current operating conditions of the vehicle **20**, based on data sensed contemporaneously, from various sensors of the vehicle **20**, such as but not limited to a brake fluid pressure sensor at a brake caliper of each wheel **32**, or a vehicle **20** speed sensor.

The detailed description and the drawings or figures are supportive and descriptive of the disclosure, but the scope of the disclosure is defined solely by the claims. While some of the best modes and other embodiments for carrying out the claimed teachings have been described in detail, various alternative designs and embodiments exist for practicing the disclosure defined in the appended claims.

The invention claimed is:

1. A vehicle comprising:

a body extending along a longitudinal axis, wherein the body defines an air intake opening configured for receiving a flow of air;

at least one duct having an air inlet disposed adjacent the air intake opening for receiving the flow of air through the air intake opening, a first outlet in fluid communication with the air inlet and configured for directing the flow of air across a brake system, and a second outlet in fluid communication with the air inlet and configured for directing the flow of air across an exterior surface of a wheel to form an air curtain over the wheel; and

an airflow control mechanism moveable between a first position for directing the flow of air through the first outlet and blocking airflow through the second outlet, and a second position for directing the flow of air through the second outlet and blocking airflow through the first outlet.

2. The vehicle set forth in claim **1** wherein the air inlet provides the flow of air to both the first outlet and the second outlet.

3. The vehicle set forth in claim **1** wherein the airflow control mechanism includes a shutter disposed within the at least one duct, wherein the shutter opens fluid communication between the air inlet and the first outlet and closes fluid communication between the air inlet and the second outlet when disposed in the first position, and wherein the shutter opens fluid communication between the air inlet and the second outlet and closes fluid communication between the air inlet and the first outlet when disposed in the second position.

4. The vehicle set forth in claim **3** wherein the airflow control mechanism includes an actuator coupled to the shutter and operable to move the shutter between the first position and the second position.

5. The vehicle set forth in claim **4** wherein the actuator includes one of an electronic actuator, a pneumatic actuator, a vacuum actuator, or a hydraulic actuator.

6. The vehicle set forth in claim **5** wherein the airflow control mechanism includes a vehicle controller having tangible, non-transitory memory on which is recorded computer-executable instructions including an air control module, and a processor configured for executing the air control module, wherein the air control module is configured for determining an optimal position for the shutter for the current operating conditions of the vehicle, and signaling the actuator to position the shutter in the optimal position.

7. The vehicle set forth in claim **3** wherein the at least one duct includes an inlet duct portion, a first duct outlet portion, and a second duct outlet portion, and wherein the shutter is disposed at an intersection of the inlet duct portion, the first duct outlet portion, and the second duct outlet portion.

8. The vehicle set forth in claim **1** wherein the airflow control mechanism is moveable into a third position, wherein the third position is disposed between the first position and the second position, and is configured to simultaneously open fluid communication between the air inlet and both of the first outlet and the second outlet.

9. The vehicle set forth in claim **1** wherein the body defines a wheel well disposed axially rearward of the air intake opening, along the longitudinal axis.

10. The vehicle set forth in claim **9** further comprising a wheel and a brake system disposed within the wheel well.

11. The vehicle set forth in claim **10** wherein the second outlet is disposed adjacent a forward edge of the wheel well, adjacent a lateral, exterior side surface of the body.

12. The vehicle set forth in claim **11** wherein the first outlet is disposed laterally inboard of the second outlet, relative to the longitudinal axis.

13. The vehicle set forth in claim **1** wherein the body extends along the longitudinal axis between a forward end and a rearward end, and the air intake opening is disposed adjacent the forward end of the body.

14. A vehicle comprising:

a body extending along a longitudinal axis, wherein the body defines an air intake opening configured for receiving a flow of air, and a wheel well disposed axially rearward of the air intake opening, along the longitudinal axis;

a wheel and an associated brake system disposed within the wheel well;

at least one duct having an air inlet, a first outlet, and a second outlet;

wherein the air inlet is disposed adjacent the air intake opening for receiving the flow of air through the air intake opening;

wherein the second outlet is positioned adjacent a forward edge of the wheel well, adjacent a lateral, exterior side surface of the body, is disposed in fluid communication with the air inlet, and is configured for directing the flow of air across an exterior surface of the wheel to form an air curtain over the wheel;

wherein the first outlet is disposed laterally inboard of the second outlet, relative to the longitudinal axis, is disposed in fluid communication with the air inlet, and is configured for directing the flow of air across the brake system to cool the brake system;

a shutter disposed within the at least one duct, and moveable between a first position and a second position, wherein the shutter opens fluid communication between the air inlet and the first outlet and closes fluid communication between the air inlet and the second outlet when disposed in the first position, and wherein the shutter opens fluid communication between the air inlet and the second outlet and closes fluid communication between the air inlet and the first outlet when disposed in the second position; and

an actuator coupled to the shutter and operable to move the shutter between the first position and the second position.

15. The vehicle set forth in claim **14** wherein the air inlet provides the flow of air to both the first outlet and the second outlet.

16. The vehicle set forth in claim **14** further comprising a vehicle controller having tangible, non-transitory memory on which is recorded computer-executable instructions including an air control module, and a processor configured for executing the air control module, wherein the air control module is configured for determining an optimal position for the shutter for the current operating conditions of the vehicle, and signaling the actuator to position the shutter in the optimal position.

17. The vehicle set forth in claim **14** wherein the at least one duct includes an inlet duct portion, a first duct outlet portion, and a second duct outlet portion, and wherein the shutter is disposed at an intersection of the inlet duct portion, the first duct outlet portion, and the second duct outlet portion.

18. The vehicle set forth in claim **14** wherein the body extends along the longitudinal axis between a forward end and a rearward end, and the air intake opening is disposed adjacent the forward end of the body.

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